A NEW RAT TAPEWORM, *SCHIZOTAENIA SIGMODONTIS,* FROM NORTH AMERICA

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During the summer of 1920, while the writers were engaged in an examination of rats of various kinds for evidence of plague infection, a considerable number of specimens of the East Texas cotton rat, *Sigmodon hispidus texianus,* were brought to the laboratory for examination, and were found to harbor a tapeworm of the family Anoplocephalidae which proved to be a new species.

The East Texas cotton rat is an extremely common rodent throughout the humid portion of eastern Texas, and is a sub-species of the common cotton rat of the Southeastern States. It lives around the edges of fields and woods, making runways under dense vegetation or brush, and feeding on vegetation almost exclusively, devouring stems, leaves, seeds and fruits. No evidence of insect remains were found in numerous stomachs examined. Of 96 rats examined, 73, or 75 per cent., were found to be parasitized by the tapeworm here described. The number present in each rat varied from one to thirty, six to ten being the most frequent numbers found.

The worm is a typical representative of the genus Schizotaenia as characterized by Douthitt (1914), except with respect to the uterus, which will be discussed later. In general morphology and anatomy, again excepting the uterus, it seems to come nearer to *Schizotaenia americana* of porcupines than to any other described species, though in the branched excretory system and relatively enormous cirrus and cirrus pouch it approaches *Schizotaenia anoplocephaloides,* described by Douthitt from gophers, *Geomys breviceps,* at Norman, Oklahoma. It is interesting to note in this connection that the only other helminth found in the cotton rat is *Protospirura ascaroidea,* hitherto described only from the same species of gopher, and from the same locality, as *Schizotaenia anoplocephaloides.* Gophers and cotton rats live in much the same way, and it is not surprising to find this similarity in their parasites. The occurrence of a Protospirura in both may be taken as strong circumstantial evidence that both eat insects with the vegetable diet, since the entire group of nematodes to which Protospirura belongs are, so far as known, dependent on invertebrates as intermediate hosts.

The worm here described, which is named *Schizotaenia sigmodontis,* is very variable in size, even among specimens from an individual host.

Mature strobilae range from 21.5 mm. to 65 mm. in length, but the smallest specimens still have a rounded sterile terminal segment, reminiscent of the button on a rattlesnake's rattle. The longest specimens, on the other hand, have an unusually large number of ripe proglottids adhering. Average specimens measure from 30 to 50 mm. in length. The number of proglottids in mature specimens varies from 70 to 90.

With the exception sometimes of one or two terminal segments, the proglottids are all wider than long, those at the middle of the strobila about five times as wide as long. The worm rapidly increases in width behind the head (Fig. 1), and reaches a maximum width of from 2.5 to 3.5 mm. Segments in the middle of the strobila are from 0.45 to 0.65 mm. in length, but back of the middle the proglottids become longer and narrower, those near the end sometimes measuring a little over one half the width of the middle proglottids, and nearly four times their length. The segments project considerably at their posterior margins (Fig. 1), but overlap each other only a little (Fig. 3, *O.*) The genital pores alternate regularly with few exceptions; they are placed near the middle of the lateral margin of the segment and are directed posteriad. The very long and conspicuous cirri, which constitute the most striking feature of the worm, can usually be seen protruding from pores in the posterior portion of the strobila.

The scolex (Fig. 2) is also variable in size, but in a majority of specimens is 0.36 to 0.45 mm. in diameter and about one-half as long; it is not sharply defined from the neck. The very muscular suckers are about 0.16 mm. in diameter. There is no evidence of a rostellum of any kind.

Segmentation begins about 0.6 mm. from the anterior end, thus leaving a short unsegmented neck, unlike other members of the genus. The beginnings of the genital ducts can be faintly observed in very early segments. The vagina and sperm ducts become differentiated out of the common foundation in about the sixteenth segment (2 mm. from the anterior end), and the beginnings of the female genital glands appear at about the same time. The cirrus pouch, cirrus and genital cloaca reach a remarkable degree of development (Fig. 5). The pouch reaches a length of 0.6 mm., about one-fifth the width of the proglottid, with a diameter of 0.19 mm. It has a heavy coat of outer longitudinal and inner circular muscle fibres. The coat of circular muscles is thickened into a distinct sphincter which partially divides the pouch into proximal and distal portions (Fig. 5, *s.m.*). The cirrus becomes greatly elongated, and an enlargement of the seminal vesicle develops in the cirrus pouch behind it, occupying a variable amount of space according to its degree of distension with the seminal fluid (cf. Figs. 4, 5 and 8). The genital papilla, as can be seen from figures 5 and 8, is the everted or partially

everted genital cloaca; it can be protruded 0.38 mm. beyond the margin of the proglottid. The extremely elongated cirrus can be extended 0.75 mm. beyond the genital papilla. When withdrawn into the genital papilla and cirrus pouch, the lumen of the cirrus and a short crown over its opening are covered with numerous fine spines. When protruded, the spines come to lie on the outside of the cirrus, but are very easily broken off, as Douthitt has pointed out in the case of other Schizotaeniae. Probably the spines are lost as the result of copulation, since the cirrus, even in very carefully handled specimens, often appears quite smooth on its exposed surface. The condition shown in Fig. 5 is probably due to a more extensive protrusion than had previously occurred, resulting in the spines near the tip not having been rubbed off.

The elongated seminal vesicle is only slightly convoluted (Figs. 4, 7) and passes toward the anterior margin of the proglottid; it becomes abruptly narrowed and turns postero-medially as the vas deferens, dividing into right and left vasa efferentia. In segments where the copulatory apparatus is evidently in functional condition, the seminal vesicle is often greatly distended with the seminal fluid. The testes, about 70 in number, are arranged in a band extending almost from one excretory canal to the other, toward the posterior side of the segment (Figs. 3, 4). The majority of the testes lie on the aporose side of the genital glands, but some lie dorsal to the glands themselves and about eight or ten are on the pore side. The testes appear to be at the height of their development, with maximum diameters of about 60μ to 85μ, in the segments in which the uterus begins its development, but the copulatory apparatus remains in a functional state almost if not quite to the end of the strobila, and the seminal vesicles continue to contain seminal fluid after the eggs are developed.

The female reproductive system, consisting of ovary, yolk gland, shell gland, seminal receptacle and vagina, becomes fully developed in about the forty-eighth segment (Fig. 4), 12 to 15 mm. from the anterior end. The vagina opens into the genital cloaca just anterior and ventral to the opening of the male system (Fig. 4, 5, 6, 7). There is usually a dilation of the tube into a pouch of variable size, shape and position, which is sometimes larger than the more regular seminal receptacle which follows it (Figs. 6 and 7); often these two pouches are connected by a very short, narrow twisted duct. The receptacle is very large and conspicuous, reaching a length of 0.3 mm. and a width of 0.15 mm. A very delicate duct passes from it in a medio-posterior direction and branches into a duct leading to the shell gland and vittelarium, and a short oviduct (Fig. 7). The large shell gland lies dorsally over the yolk gland, and is about 0.15 mm. in diameter. The ovary and yolk gland are only a little displaced toward the pore side (Figs. 3 and 4); the ovary surrounds the bilobed yolk gland in a

crescentic manner. The yolk gland is bilobed, the median lobe being larger, and each lobe is subdivided into small radiating lobules, as described by Douthitt in *S. americana*. In cleared unstained segments in which the uterus is undergoing development, the yolk gland appears filled with a dense yellowish substance.

The uterus of *S. sigmodontis* is of particular interest. The development of the uterus of the genus Schizotaenia has long been a matter of doubt. Stiles (1897) describes the uterus in *Bertia americana* and *Bertia americana leporis*, both later referred to Schizotaenia, in a very indefinite manner; in the former worm he states that the development of the uterus could not be followed in detail and in the latter that the uterus spreads from the female glands. Janicki (1904) separated the genus Schizotaenia from Bertia (later changed to Bertiella) largely on the basis of the uterus. In Bertiella the uterus develops as a transverse tube with anterior and posterior egg pouches, whereas Janicki described the uterus in Schizotaenia (*S. hagmani*) as developing by a horizontal splitting of the parenchyma from which the uterus extends laterally by means of out-pocketings, and into the rest of the proglottid by a complicated "spaltenwerk." Douthitt, in 1914, described the uterus of *S. americana* as first recognizable as an extensive sheet of tissue which thickens in definite lines and may represent a degenerate reticulum. In *S. anoplocephaloides* he described it as first appearing as a sheet of cells dorsad of the ovary and ventrad of the testes, with circular thickenings around the margins of the testicular fields connected by a transverse thickening, and with a network of less conspicuous strands, again suggesting a degenerate reticulum. The transverse and circular bands develop into canals and the eggs pass by way of the transverse canal to the circular canals. The latter expand centrad and the transverse canal anteriad, until the cavity of the uterus becomes one continuous sac. The extension from this stage is by a regular out-pocketing. Douthitt believes that the difference in the description of the uteri given by himself and by Janicki is one of interpretation rather than of structure.

Schizotaenia sigmodontis, in spite of its evident close similarity to *S. americana* and *S. anoplocephaloides* in other respects, differs absolutely in the mode of development of its uterus. In this species the ovary itself becomes the central portion of the uterus and radiating out-pocketings make their appearance (Fig. 6) from the periphery of the ovary, not only laterad and anteriad, but dorsad and ventrad also. The radiating branches rapidly fill up the middle field of the proglottid, with the exception of the space occupied by the seminal receptacle, shell gland and testes. The out-pocketings are never empty tubes but seem rather to be formed in consequence of pressure exerted by the rapidly developing and enlarging ova.

It is difficult to correlate this unique type of uterine development with the types described in other Schizotaeniae, but a suggestion may be made. Douthitt believes that the sheets of uterine tissue found in Schizotaeniae represent degenerate reticula. In *S. anoplocepholoides* only the peripheral portions of the sheet develop into canals; the rest of the sheet is nonfunctional. In *S. americana* and *S. variabilis* there is no evidence that any part is functional. Douthitt was unable to follow the uterine development in detail in either species beyond the sheet of tissue which he took to represent a degenerate reticulum, and jumps, in his description, from this stage to the fully developed uterus. It is possible that in these forms the uterus develops as it does in *S. sigmodontis*. If the reticulum should entirely degenerate, the out-pocketing which in *S. anoplocephaloides* arises from the periphery of the part which remains functional would naturally arise from the periphery of the ovary. Possibly the splitting of the parenchyma described by Janicki in *S. hagmani* results from an overdistension of the ovary, which may subsequently burst, the out-pocketing at the edges of the split being developed as the natural response on the part of the parenchyma to the presence of ova. If this is a correct interpretation, *S. hagmani* may be looked upon as illustrating an intermediate stage between *S. anoplocephaloides* and *S. sigmodontis*.

The eggs (Fig. 9) are globular and possess three envelopes. The rather heavy outer shell has a diameter of from 47μ to 53μ. The delicate middle membrane is oval, 33μ by 27μ; the inner membrane immediately surrounds the oncosphere and possesses a typical pyriform apparatus. The oncosphere is 16μ to 18μ in diameter and not quite spherical. The pyriform apparatus is 10μ in length. Apparently the eggs are not normally shed from the proglottids within the body of the host, since they have never been found in the centrifuged feces of infected animals.

The excretory system in *S. sigmodontis* consists of a pair of slender thick-walled dorsal vessels and a pair of very spacious ventral vessels connected by broad transverse tubes, and by a system of anastomosing branches (Fig. 8) more extensive than in other species of Schizotaenia. The longitudinal nerves do not show clearly except near the scolex, where they can be seen lying considerably laterad of the excretory canals. The latter cross the reproductive tubes ventrally. Calcareous corpuscles are present and moderately abundant. Following is a diagnosis of the species:

Schizotaenia sigmodontis, n.sp., Chandler and Suttles, 1922

Diagnosis: Strobila 21.5 to 65 mm. long by 2.5 to 3.5 mm. in maximum breadth, segments, except sometimes terminal ones, broader than long. Proglottids 70 to 90. Scolex unarmed, about 0.38 to 0.45 mm. in diameter, about half this length, not sharply demarcated from

the neck; suckers 0.16 mm. in diameter. Strobilization begins about 0.6 mm. from anterior end. Genital pores regularly alternate, near middle of lateral margins of segments. Cirrus very long, spinous; cirrus pouch large, containing enlargement of seminal vesicle; latter, medial of cirrus pouch, slightly convoluted. Testes about 70 in number, 60μ to 85μ in diameter, in posterior band in median field, more numerous on aporose side; female genital glands slightly displaced toward pore side; ovary crescentic; yolk gland bilobed with radiating lobules; shell gland large; uterus develops as radiating out-pocketings from ovary itself, eventually occupying entire median field as coarse anastomosing branched pouches; ova globular, with three membranes and pyriform apparatus; outer shell 47μ to 53μ in diameter, oncosphere 16μ to 18μ in diameter, pyriform apparatus 10μ long. Calcareous corpuscles present.

Host: Cotton rat, *Sigmodon hispidus texianus*. Life history: Unknown. Types sent to U. S. National Museum.

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Explanation of Plate XIII

Abbreviations Used

cl cloaca, *ct* loose connective tissue, *gp* genital papilla, *o* area of overlapping of segments, *od* oviduct, *ov* ovary, *sg* shell gland, *sm* sphincter muscle, *sp* spines of cirrus, *sr* seminal receptacle, *sv* seminal vesicle, *t* testes, *u* uterine out-pocketings, *v* vagina, *yg* yolk gland.

Fig. 1.—*Schizotaenia sigmodontis*, mature worm, showing protruded cirri and sterile terminal segment. × 1.5.

Fig. 2.—Scolex, neck and anterior proglottids. × 40.

Fig. 3.—Young proglottid, the 36th, showing reproductive organ in early state of development. × 30.

Fig. 4.—Older proglottid, the 47th, just prior to development of uterine out-pocketings, showing fully developed female reproductive organs; testes well developed, but copulatory apparatus not yet functional. × 30.

Fig. 5.—Copulatory apparatus and vagina. × 65.

Fig. 6.—Fifty-second proglottid, showing beginning of development of uterus by radiating outpocketings from ovary. × 30.

Fig. 7.—Left half of mature proglottid showing relationships of genital and excretory ducts as seen from dorsal side. × 30.

Fig. 8.—Mature proglottids showing branched excretory system. × 10.

Fig. 9.—Uterine ova. × 400.

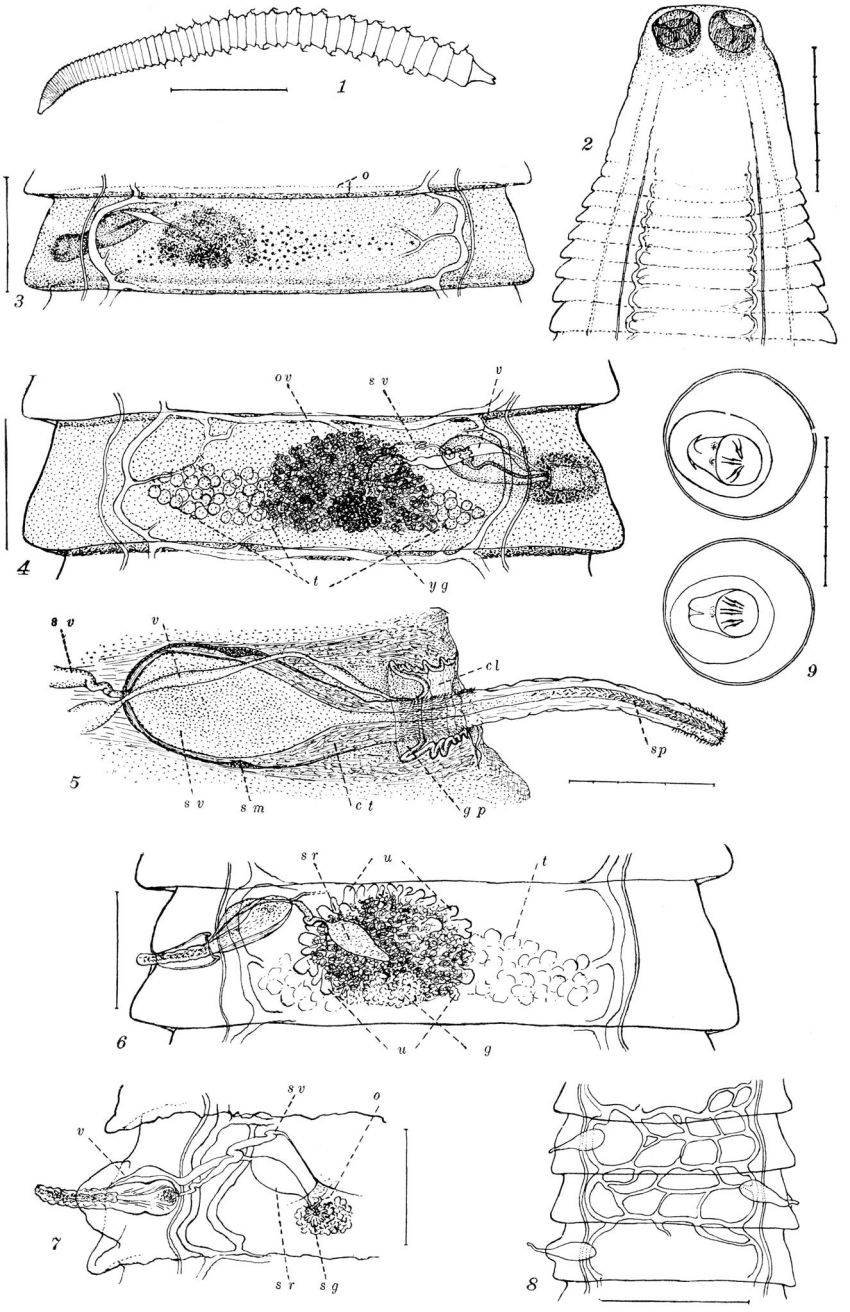

PLATE XIII